MASTER

Optical Characterization of Hexagonal Silicon Germanium Quantum wells and Mahan excitons

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Abstract

Hexagonal silicon germanium (hex-Si_xGe_{1-x}) has been proven to be a direct band gap material and an efficient light emitter for low x [1]. This can enable group-IV compatible light sources, which could enable fully integrated photonics on computer chips, speeding up on-chip communication. Another possible application is the miniaturisation of gas sensors, which need sources and detectors of mid-infrared light.

In this project, hex-SiGe nanowires have been characterised using photoluminescence (PL) spectroscopy, with a focus on two topics. Firstly, Ge quantum wells in hex-Si_xGe_{1-x} with $x \approx 0.2$ have been investigated. Quantum confinement is proven using measurements of quantum wells with different thicknesses. Strong peak broadening due to a large spread in the width of the grown wells is observed. At high excitation density, spill over effects from the quantum well to the barrier states are found, which could indicate quasi-type-II band alignment. Nevertheless, it was concluded that the quantum well is of type-I, where both carriers are confined inside the well. For the widest quantum well, light emission from the quantum well is observed up to room temperature.

The second part of the project involves the investigation of the Mahan exciton in hex-Ge and hex-SiGe nanowires. These are observed as a peak at an energy above the band gap, which appears at low temperature and low excitation power in the PL spectra at the electron quasi-Fermi level. Simulations of the PL spectra have been performed using the Lasher-Stern-Würfel model [2, 3], which has been extended with a Coulomb interaction between the carriers to describe excitons. However, the current model did not accurately reproduce the Mahan exciton. It has been found that hole localisation is of key importance to describe the Mahan exciton, so the model has to be adapted to allow for the violation of momentum conservation.